Low energy cooling related beam experiments

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Low Energy RHIC electron Cooling (LEReC)

- Luminosity at low energies (below nominal injection energy) has to be increased by at least a factor 3 for BES-II

- Up to 5.75 GeV, Low Energy RHIC electron Cooling

- Above 5.75 GeV, luminosity increase has to come from higher intensity and/or smaller β^*

- APEX proposals aim at cooling diagnostics, and intensity increase/β^* reduction

Cooling diagnostics

1. Beam energy (=velocity) measurements

   - Electron cooling requires overlap of electron and ion beam in transverse position and longitudinal velocity

   - Transverse positions: BPMs

   - Longitudinal velocity is most challenging

Velocity measurement/calibration idea:

- Inject and debunch ion beam
- Turn on electron cooler
- Observe longitudinal Schottky spectrum
- Spike in longitudinal Schottky spectrum indicates where electron and ion velocity are equal, resulting in cooling

APEX experiment in 2016:
Measure momentum acceptance by observing Schottky spectrum of debunched beam to determine maximum observable velocity offset (4 hours)

2. Cooling optimization

- Cooling results in electron capture by the Au^{79+} ions (recombination)

- Detecting the resulting Au^{78+} ions provides a "luminosity" signal for tuning

- $B\rho$ for Au^{78+} is 1.25 percent higher, resulting in a dispersive orbit

- Detecting Au^{78+} requires a location with large dispersion and small β :

$$\frac{\Delta p}{p} \times D > 5\sigma_x = 5\sqrt{\epsilon\beta_x}$$

- Such a location does not exist in the regular RHIC lattice

Two APEX proposals:

- Dedicated “high dispersion” lattice has been developed by Felix Carlier (CERN)

- Implement and test this lattice at injection energy (6-8 hours)

- Generate small beam loss in dedicated location to test detectability outside the cryostat (4 hours, could be regular lattice as well)

Luminosity increase above 5.75 GeV

- RHIC has operated with 1.1×10^9 and $\beta^* = 3.5\,\mathrm{m}$ at 7.3 GeV, and 0.9×10^9 and $\beta^* = 2.5\,\mathrm{m}$ at 9.8 GeV

- This may not have been the optimum parameter set for integrated luminosity

APEX proposal:
Prepare injection energy lattices with different values of β^*, and collide beams of varying intensity. Find parameter combination for maximum integrated luminosity (16 hours)